Effect of difference of throughfall drop characteristics for surface runoff generation on bared forest floor

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Poorly managed Japanese cypress plantations in Japan suffer from soil erosion because they have little surface cover. Throughfall has larger kinetic energy and spatial variability under the canopy than open rainfall. The spatial variability of throughfall should affect the spatial heterogeneity of surface runoff generation because the infiltration rate depends on the rainfall rate and kinetic energy. To estimate surface runoff generation at a bare surface in a forested area, indoor experiments were conducted using 13 runoff boxes and a single transplanted Japanese cypress tree 9.8 m in height in a large-scale rainfall simulator with spray nozzles at a height of 16 m.

Continuous rainfall was applied at the following two rates: 39.8 mm h^{-1} for 15 min (lower rainfall rates: Rain-L) and 85.2 mm h^{-1} for 20 min (higher rainfall rates: Rain-H). Surface runoff was measured for throughfall and for rainfall applied at different rainfall rates and kinetic energies among measurement points and canopy structures in four applied rainfall events. To estimate the effect of the impact of drops with high kinetic energy, we used the effective unit kinetic energy ($KE_{0.mm}$). $KE_{0.mm}$ is accumulation of kinetic energy of drops with more than a threshold kinetic energy, 0.1 mJ in this study.

Throughfall had larger kinetic energy than the applied rainfall, in particular much larger effective kinetic energy. $KE_{0.mm}$ was 0.4 J m^{-2} mm^{-1} in the applied rainfall, in contrast from 5.0 to 18.1 J m^{-2} mm^{-1} under the canopy. While no surface runoff was observed for the applied rainfall, surface runoff was observed for throughfall in each runoff box. Surface runoff varied among the runoff boxes in each rainfall event. The surface runoff during Rain-H in the fourth applied event among the 12 measurement points under the canopy were 26.0 mm h^{-1} in mean and 15.5 mm h^{-1} in standard deviation, ranging from 2.6 to 47.3 mm h^{-1}. Surface runoff showed positive correlation with rainfall rates, but the high $KE_{0.mm}$ increased surface runoff when the rainfall rate was similar. These results suggest that surface runoff generation depends not only on the rainfall rate but also on the impact of drops with high kinetic energy.